Using the TPS22965EVM-023

The TPS22965EVM-023 evaluation module contains a single channel, ultra-low ON-resistance, 6-A load switch with controlled turn and adjustable rise time.

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1 Description

The TPS22965 device is a small, ultra-low ON-resistance (R_{ON}) single-channel load switch with controlled turn on. The device contains an N-channel MOSFET that can operate over an input voltage range of 0.8 to 5.5 V and can support a maximum continuous current of up to 6 A. The switch is controlled by an active high on and off input (ON), which is capable of interfacing directly with low-voltage GPIO control signals.

In the TPS22965 device, a 225-Ω on-chip load resistor is added for quick output discharge (QOD) when the switch is turned off. The rise time of the device is internally controlled in order to avoid in-rush current and can be adjusted using an external ceramic capacitor on the CT pin.

The TPS22965 device is available in a small, space-saving 2-mm × 2-mm 8-pin SON package with integrated thermal pad allowing for high-power dissipation.

1.1 Typical Applications

- Ultrabook™
- Notebooks and Netbooks
- Tablet PC
- Consumer Electronics
- Set-Top Boxes and Residential Gateways
- Telecom Systems
- Solid State Drives (SSD)

1.2 Features

- Integrated single-channel load switch
- Input voltage range: 0.8 to 5.5 V
- Ultra-low on-resistance (20 mΩ typical)
- 6-A maximum continuous switch current
- Low threshold control inputs
- Adjustable slew-rate control
- Quick output discharge transistor
- SON 8-pin package with thermal pad

2 Electrical Performance Specifications

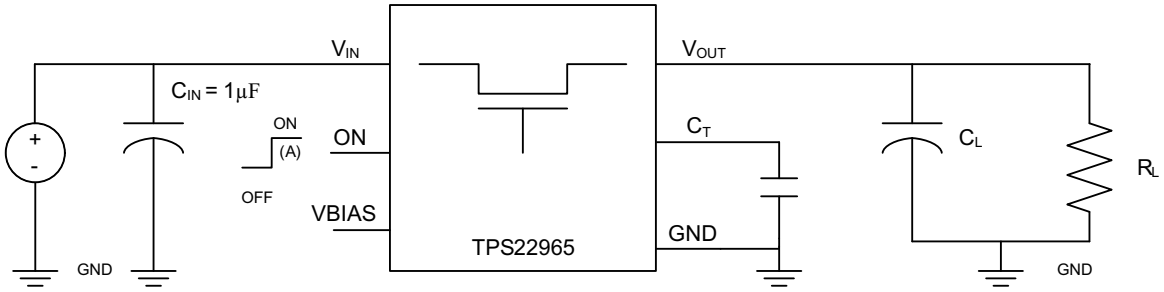
2.1 Electrical Characteristics

PARAMETER		TEST CONDITIONS		T_A	MIN	TYP	MAX	UNIT
V_{BIAS} = 5.0 V, T_A = –40°C to 85°C (unless otherwise noted)								
$I_{IN(VBIAS-ON)}$	VBIAS quiescent current	I_{OUT} = 0 V, V_{IN} = V_{ON} = 5 V		Full		50	75	µA
$IIN_{VIN-OFF}$	V_{IN} off-state supply current	V_{ON} = GND, V_{OUT} = 0 V	V_{IN} = 5.0 V	Full		0.2	8	µA
			V_{IN} = 3.3 V	Full		0.02	3	
			V_{IN} = 1.8 V	Full		0.01	2	
			V_{IN} = 0.8 V	Full		0.005	1	
$IIN_{VBIAS-OFF}$	VBIAS shutdown current	V_{ON} = GND, V_{OUT} = 0 V		Full			0.5	µA
R_{ON}	ON-state resistance	I_{OUT} = –200 mA V_{BIAS} = 5.0 V	V_{IN} = 5.0 V	25°C		16	23	mΩ
				Full			25	
			V_{IN} = 3.3 V	25°C		16	23	
				Full			25	
			V_{IN} = 1.8 V	25°C		16	23	
				Full			25	
			V_{IN} = 1.5 V	25°C		16	23	
				Full			25	
			V_{IN} = 1.2 V	25°C		16	23	
				Full			25	
			V_{IN} = 0.8 V	25°C		16	23	
				Full			25	
R_{PD}	Output pull-down resistance	V_{IN} = 5.0 V, V_{ON} = 0 V, I_{OUT} = 15 mA		25°C		225	300	Ω

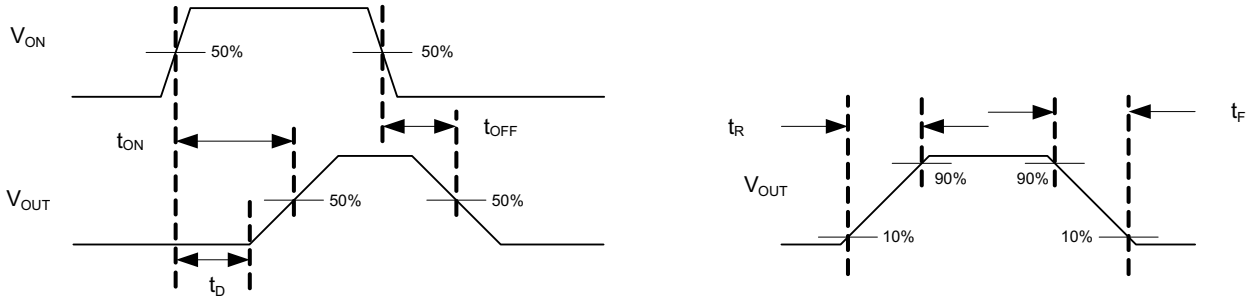
2.2 Switching Characteristics

PARAMETER		TEST CONDITIONS	EACH CHANNEL TYP	UNIT
V_{IN} = V_{ON} = V_{BIAS} = 5.0 V, T_A = 25°C (unless otherwise noted)				
t_{ON}	Turn-on time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF	1325	µs
t_{OFF}	Turn-off time		10	
t_R	V_{OUT} rise time		1625	
t_F	V_{OUT} fall time		3.5	
t_D	ON delay time		500	
V_{IN} = 0.8 V, V_{ON} = V_{BIAS} = 5.0 V, T_A = 25°C (unless otherwise noted)				
t_{ON}	Turn-ON time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF	600	µs
t_{OFF}	Turn-OFF time		80	
t_R	V_{OUT} rise time		300	
t_F	V_{OUT} fall time		5.5	
t_D	ON delay time		460	
V_{IN} = 2.5 V, V_{ON} = 5 V, V_{BIAS} = 2.5 V, T_A = 25°C (unless otherwise noted)				
t_{ON}	Turn-ON time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF	2200	µs
t_{OFF}	Turn-OFF time		9	
t_R	V_{OUT} rise time		2275	
t_F	V_{OUT} fall time		3.1	
t_D	ON delay time		1075	
V_{IN} = 0.8 V, V_{ON} = 5 V, V_{BIAS} = 2.5 V, T_A = 25°C (unless otherwise noted)				
t_{ON}	Turn-ON time	R_L = 10 Ω, C_L = 0.1 µF, CT = 1000 pF	1450	µs
t_{OFF}	Turn-OFF time		60	
t_R	V_{OUT} rise time		875	
t_F	V_{OUT} fall time		5.5	
t_D	ON delay time		1010	

SWITCHING CHARACTERISTIC MEASUREMENT INFORMATION



TEST CIRCUIT



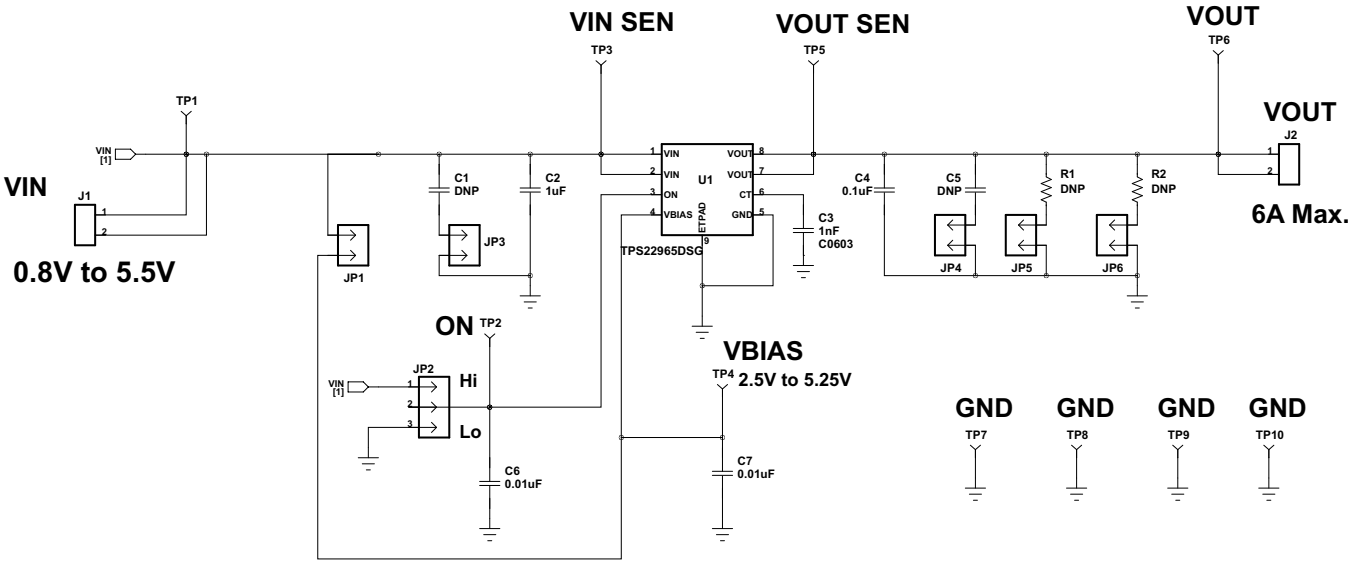
t_{ON}/t_{OFF} WAVEFORMS

(A) Rise and fall times of the control signal is 100ns.

Table 1. Trise vs VIN vs CT Cap

CT (pF)	Rise Time (µs) 10% to 90%, COUT = 0.1 µF at VIN; VOUT = 10-Ω Load Typical Values at 25°C, 25-V X7R 10% Ceramic Cap						
	5 V	3.3 V	1.8 V	1.5 V	1.2 V	1.05 V	0.8 V
0	127	93	62	55	51	46	42
220	475	314	188	162	141	125	103
470	939	637	359	304	255	218	188
1000	1869	1229	684	567	476	414	344
2200	4020	2614	1469	1211	1024	876	681
4700	8690	5746	3167	2703	2139	1877	1568
10000	18360	12550	6849	5836	4782	4089	3449

3 Schematic



1 DNP=Do Not Populate

Figure 1. TPS22965EVM-023 Schematic

4 Layout

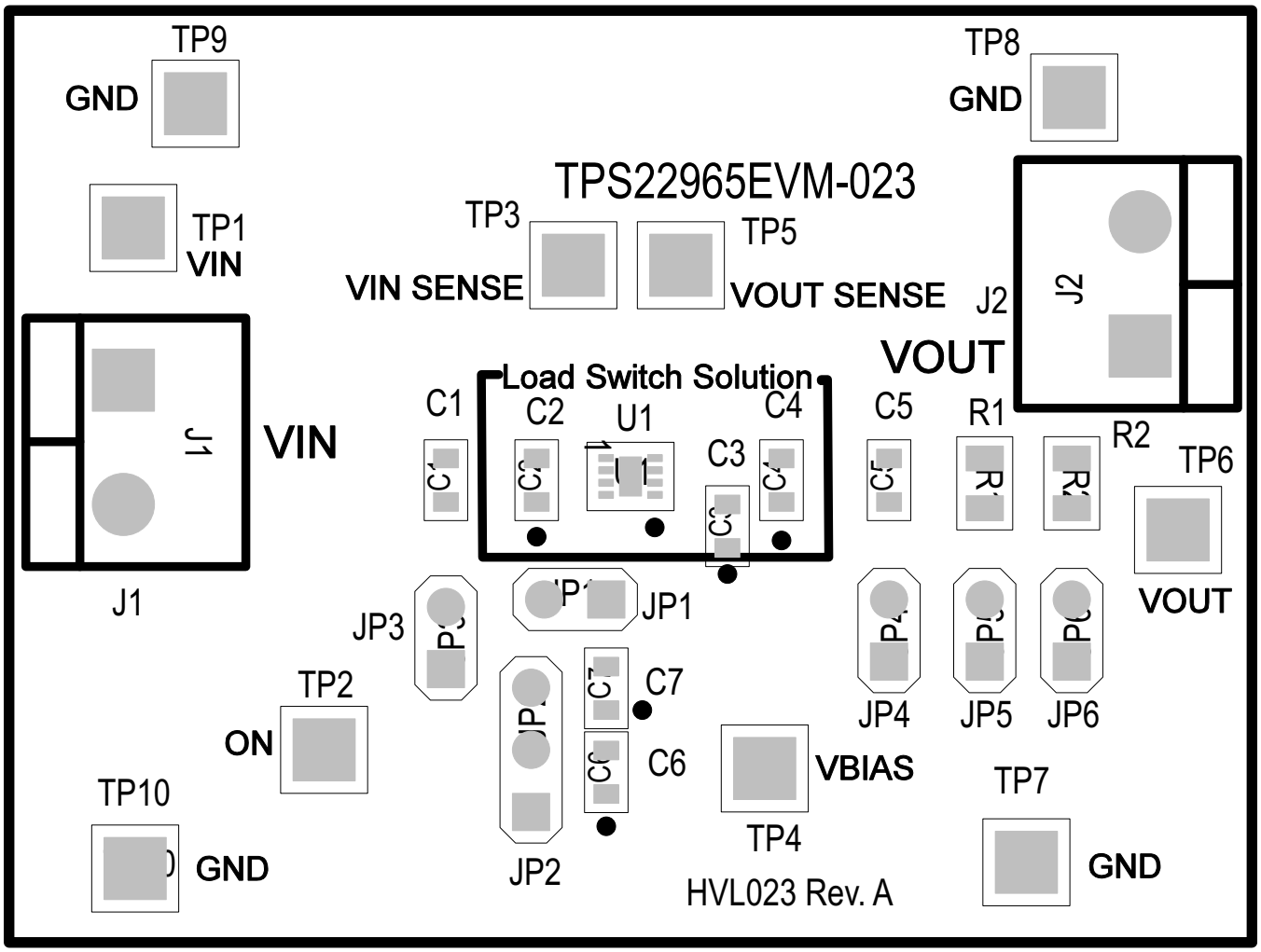


Figure 2. TPS22965EVM-023 Top Assembly

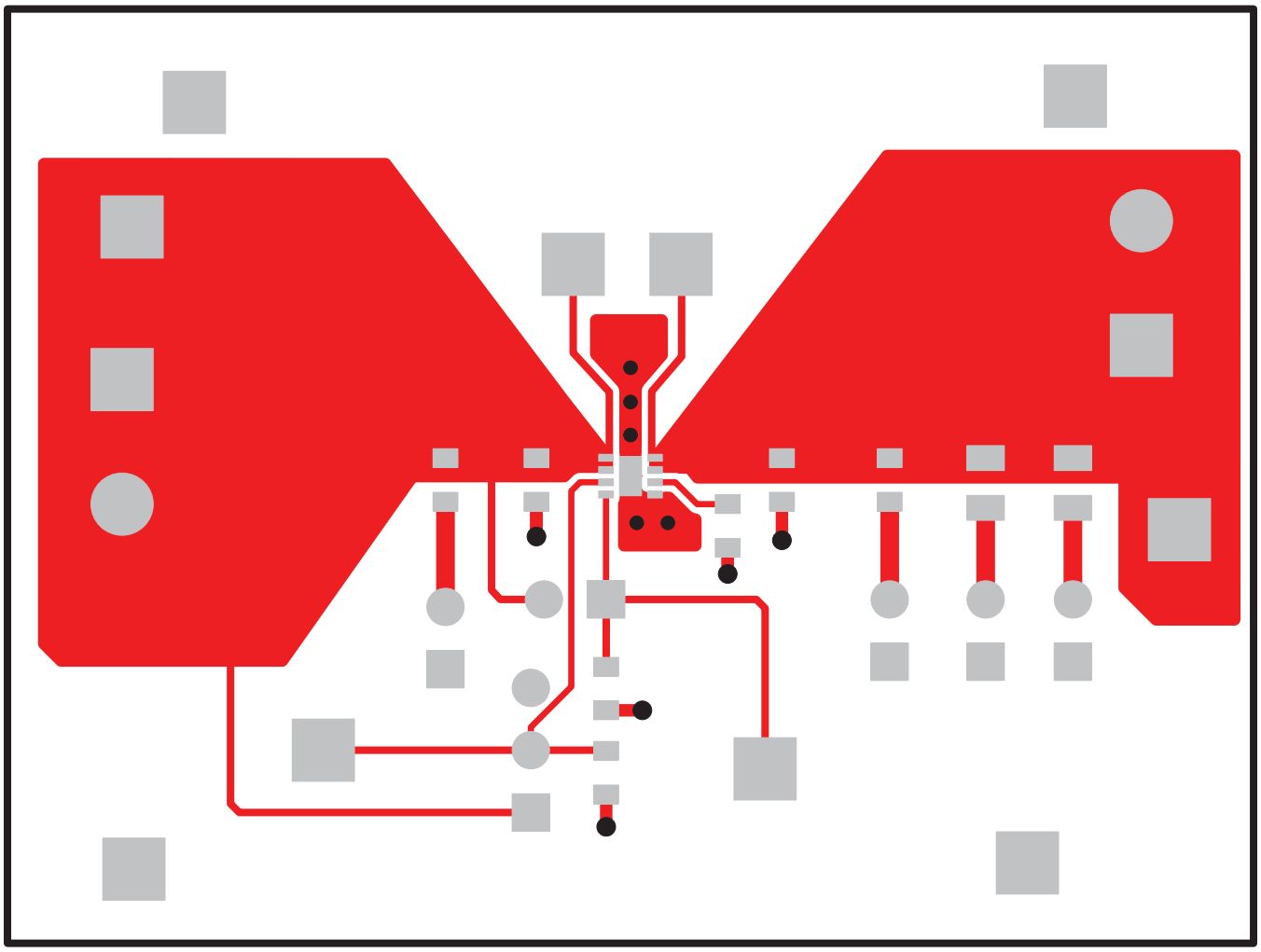


Figure 3. TPS22965EVM-023 Topside

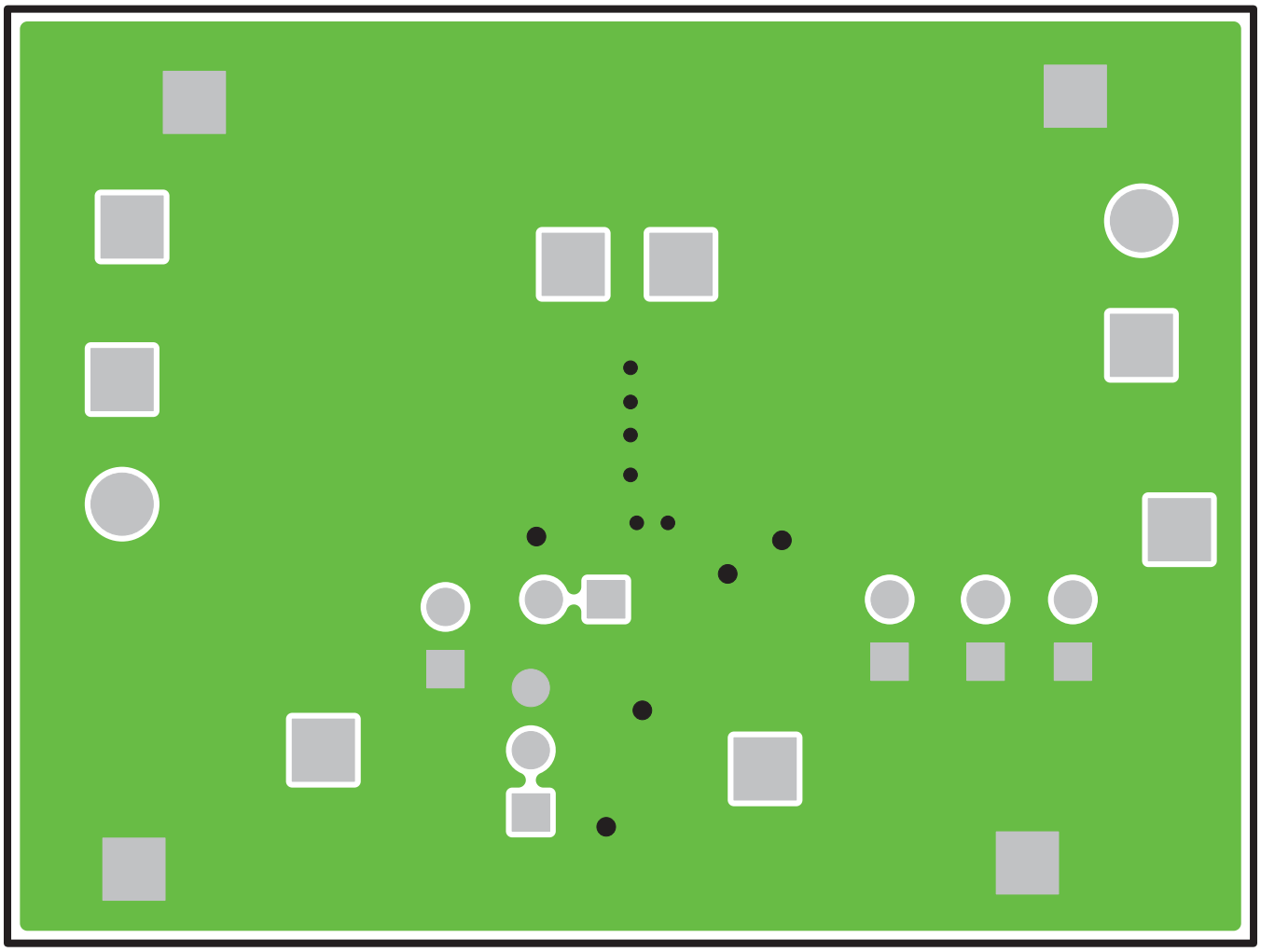


Figure 4. TPS22965EVM-023 Bottomside

5 Test Setup

5.1 Test Equipment

- **Voltage Source:**
  - One power source capable of 10 V and 10 A.
- **Multimeters:**
  - One voltmeter
- **Output Loads:**
  - Electronic load or resistor (if testing 6-A operation of the switch at 5.5 V, a 33-W power-rated resistor is needed)
- **Oscilloscope:**
  - Two-channel 100 MHz
- **Signal Generator:**
  - Dual-channel preferred
- **Recommended Wire Gauge:**
  - 18 AWG

5.1.1 List of Test Points

Table 2. The Functions of Each Test Point

Test Points	Name	Description
J1	VIN	DC Input to VIN
J2	VOUT	VOUT connection
JP1	VBIAS	Connects VBIAS to VIN
JP2	ON	Connects ON to VIN or AGND
JP3	C1	Connects C1 to VIN
JP4	C5	Connects C5 to VOUT
JP5	R1	Connects R1 to VOUT
JP6	R2	Connects R2 to VOUT
TP1	VIN	VIN of TPS22965
TP2	ON	ON of TPS22965
TP3	VIN SEN	Sense connect to VIN of TPS22965
TP4	VBIAS	VBIAS of TPS22965
TP5	VOUT SEN	Sense connect to VOUT of TPS22965
TP6	VOUT	VOUT of TPS22965
TP7	AGND	Ground connection
TP8	AGND	Ground connection
TP9	AGND	Ground connection
TP10	AGND	Ground connection

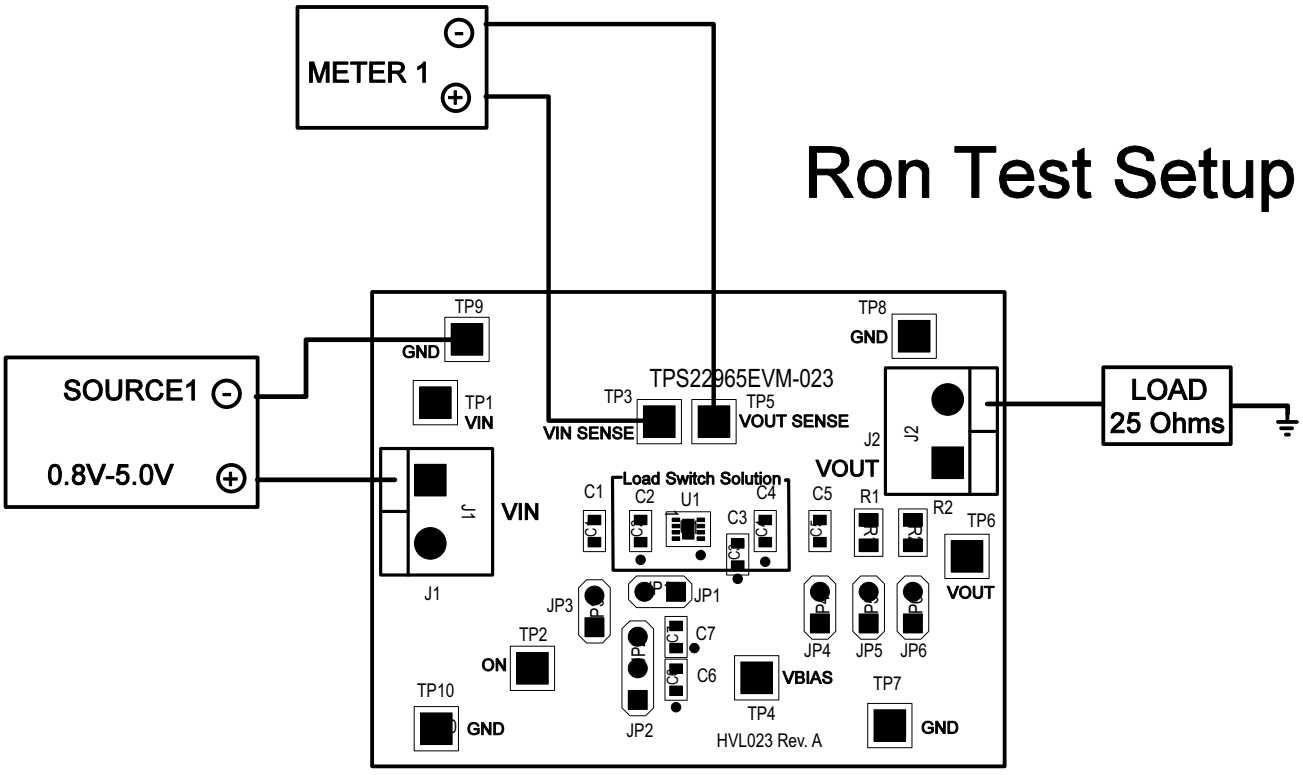


Figure 5. TPS22965EVM-023 Recommended R_{ON} Test Setup

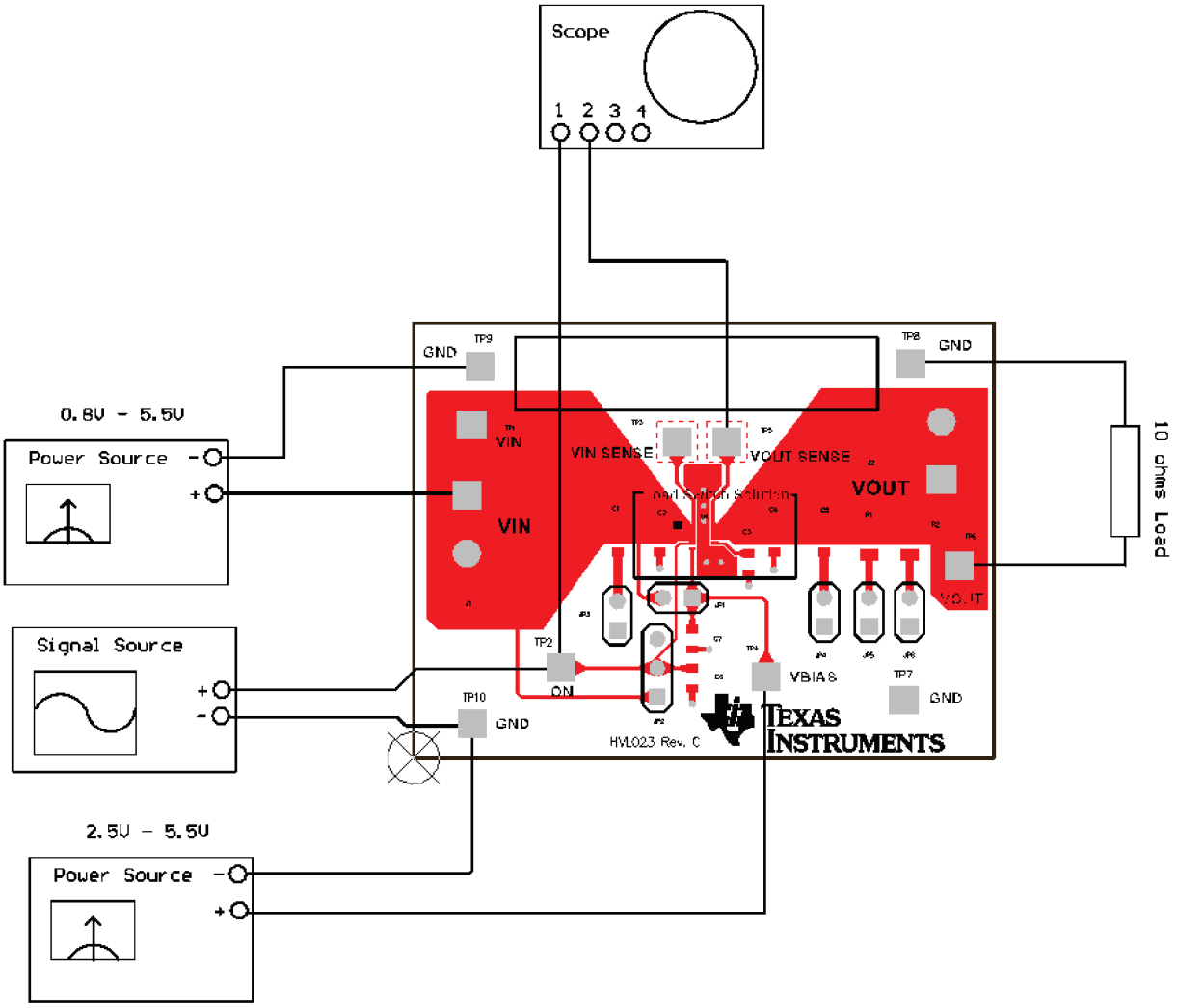


Figure 6. TPS22965EVM-023 Recommended Trise Test Setup

5.2 Test Procedure (Standalone Setup)

Figure 5 shows a typical setup for R_{ON} testing of the EVM. VBIAS voltage must be present for the device to function. Place a shunt across JP1 to connect VBIAS to VIN voltage source. If VIN supply is used below 2.5 V, remove the shunt and connect VBIAS voltage to a voltage source > 2.5 V. TI recommends operating the TPS22965 device with VBIAS = 5 V. Datasheet limits are specified with VBIAS set at 5.0 V.

5.3 R_{ON} Test Procedure

1. Setup the EVM per Figure 5.
2. Set SOURCE1 level to 5.0 V.
3. Place a shunt on JP2 shorting pins 1 to 2. This connects ON to VIN voltage. ON voltage must be between 1.05 and 5.5 V for a valid ON state.
   (When testing R_{ON}, keep the switch operating in the always ON condition.)
4. Place a load on VOUT.
5. Turn on SOURCE1.
6. Record the voltage reading from Meter1. Record the input current reading from SOURCE1. Calculate R_{ON} by dividing Meter1 voltage level by the current reading from SOURCE1. The results will be the R_{ON} value for the Switch.
7. Turn off SOURCE1.

5.4 Trise and Ton Test Procedure

1. Set up the EVM per Figure 6.
2. Set SOURCE1 level to 5.0 V. VBIAS is operational between 2.5 and 5.25 V. Datasheet limits are specified with VBIAS set at 5.0 V.
3. Remove shunt from JP2.
4. Place a load on VOUT. (A 10-Ω, 3.25-W resistor is recommended for this test).
5. Set signal generator outputs to 0 to 2 Vpp levels, 10 to 100 Hz, and 25% duty cycle. Connect signal generator output to TP2.
6. Turn on SOURCE1.
7. Turn ON the signal generator output.
8. Trise and Ton can be observed from the Oscilloscope channel2. A detailed description of Trise, Ton, Tfall, and Toff are listed in the TPS22965 datasheet under the Switching Characteristics section.
9. Turn off SOURCE1 and the signal generator output.

6 Performance Data and Typical Characteristic Curves

Figure 7 and Figure 8 present typical performance curves for TPS22966EVM-007.

6.1 Trise Curve

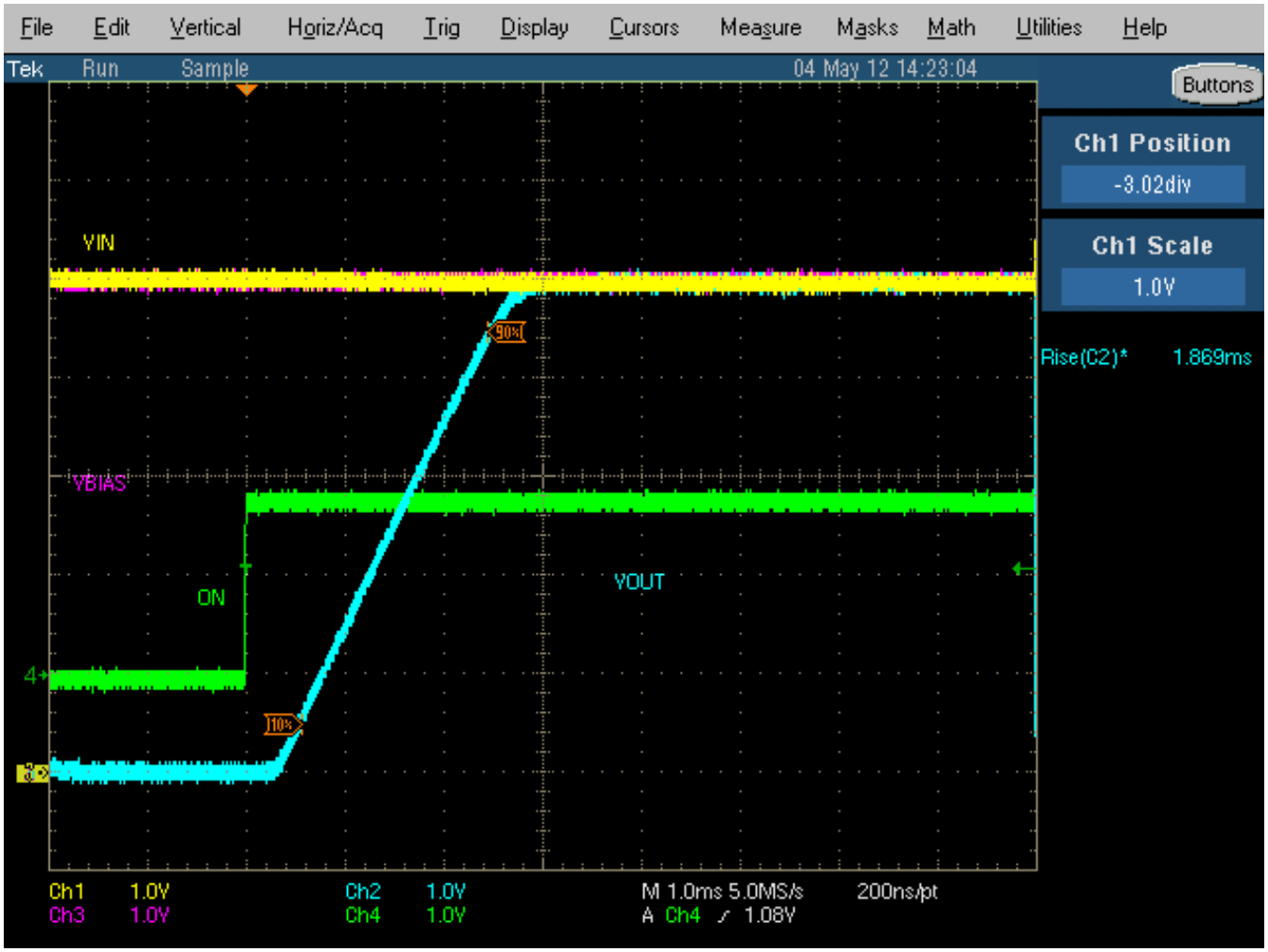


Figure 7. TPS22965EVM-023 Trise VIN = 5 V, ct = 1nF, and Load = 10 Ω

6.2 6A Operation

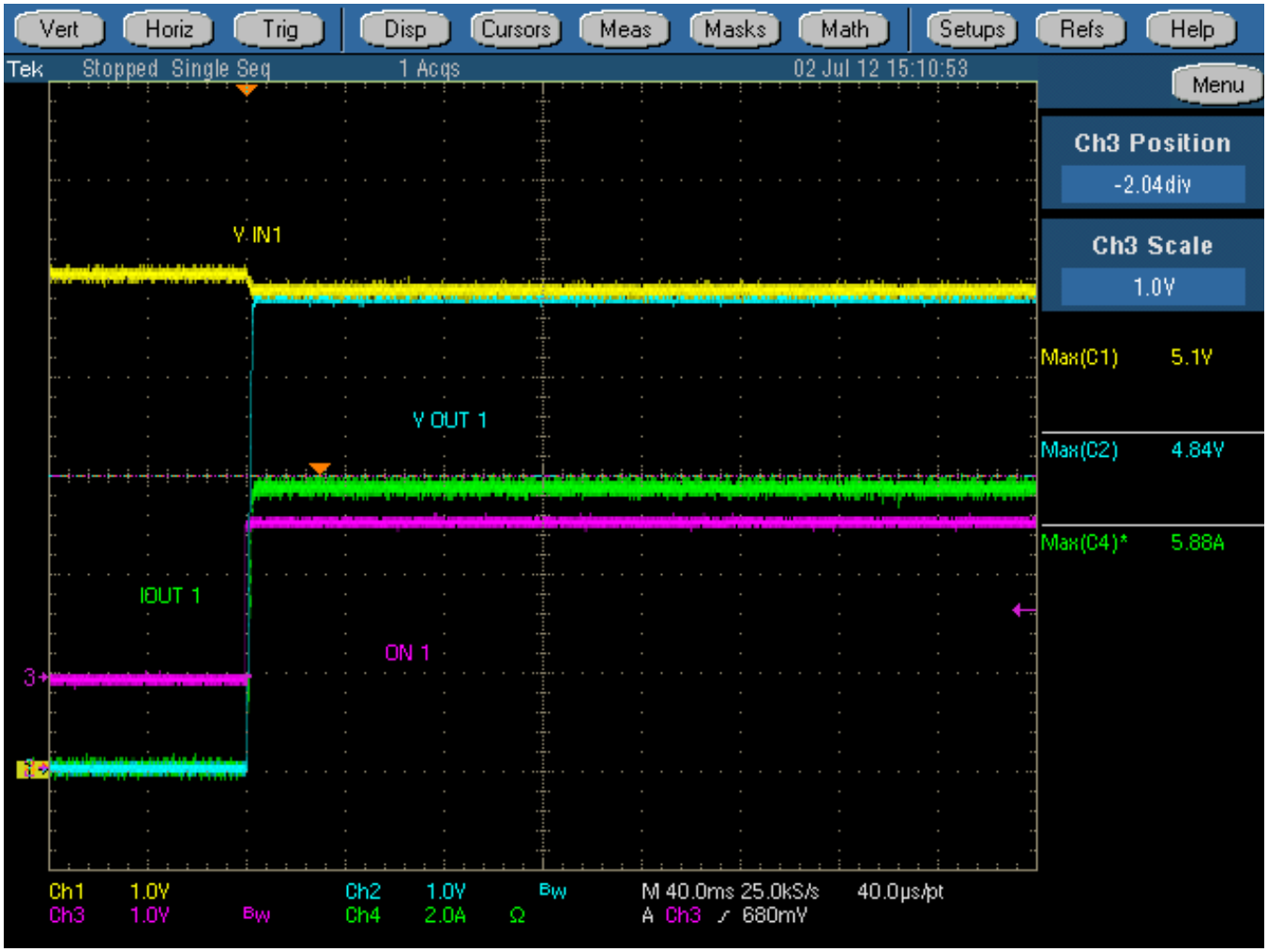


Figure 8. TPS22965EVM-023 Turn-ON and Operation at 6 A

7 Bill of Materials

This is the EVM components list according to the schematic shown in Figure 1.

Table 3. EVM Components List

Count	RefDes	Value	Description	Size	Part Number	MFR
0	C1, C5	DNP	Capacitor, ceramic, 25 V, X7R, 20%	0603	Std	Std
1	C2	1 µF	Capacitor, ceramic, 16 V, X7R, 20%	0603	Std	Std
1	C3	1 µF	Capacitor, ceramic, 25 V, X7R, 20%	0603	Std	Std
1	C4	0.1 µF	Capacitor, ceramic, 25 V, X7R, 20%	0603	Std	Std
2	C6, C7	0.01 µF	Capacitor, ceramic, 16 V, X7R, 20%	0603	Std	Std
2	J1, J2	ED120 / 2DS	Terminal block, 2-pin, 15 A, 5.1 mm	0.40 x 0.35 in	ED120/2DS	OST
5	JP1, JP3, JP4, JP5, JP6	PEC02SAAN	Header, male 2-pin, 100 mil spacing	0.100 in x 2	PEC02SAAN	Sullins
1	JP2	PEC03SAAN	Header, male 3-pin, 100 mil spacing	0.100 in x 3	PEC03SAAN	Sullins
0	R1, R2	DNP	Resistor, chip, 1 / 16 W, x%	0805	Std	Std
6	TP1, TP2, TP3, TP4, TP5, TP6	5010	Test point, red, thru-hole compact style	0.125 x 0.125 in	5005	Keystone
4	TP10, TP11, TP12, TP13	5011	Test point, black, thru-hole compact style	0.125 x 0.125 in	5006	Keystone
1	U1	TPS22965DSG	IC, 6-A load switch with controlled turn-on	SON-8	TPS22965DSG	TI
2			Shunt, black	100 mil	929950-00	3M
1	—		PCB, 2 in x 1.5 in x 0.062 in		HVL023	Any

Notes: 1. These assemblies are ESD sensitive. Observe ESD precautions.

2. These assemblies must be clean and free from flux and all contaminants. Do not use no clean flux.

3. These assemblies must comply with workmanship standards IPC-A-610 Class 2.

4. Ref designators marked with an asterisk ('**') cannot be substituted. All other components can be substituted with equivalent MFR components.

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General Statement for EVMs including a radio

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For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant

Caution

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concerning EVMs including detachable antennas

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

Concernant les EVMs avec appareils radio

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

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This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

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2. Use this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard.
3. Since the EVM is not a completed product, it may not meet all applicable regulatory and safety compliance standards (such as UL, CSA, VDE, CE, RoHS and WEEE) which may normally be associated with similar items. You assume full responsibility to determine and/or assure compliance with any such standards and related certifications as may be applicable. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM’s electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI’s recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to defend, indemnify and hold TI, its licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, "Claims") arising out of or in connection with any use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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